CURSORY REMARKS

ON THE

SUBJECT

OF

WHEEL CARRIAGES.

BY

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PREFACE.

THE subject of Carriage Wheels having appeared to persons in general considerably obscured, I am induced to offer some considerations upon it, with a view to assist as far as my humble efforts contribute in ascertaining the true principles of their application to carriages; and as the following remarks are but an attempt to throw some light on the subject, I trust they will meet with indulgence. Being only the spontaneous suggestions which have occurred to my mind (which at all events may assist in developing the truth), I hope they will be weighed with candour, and escape that critical severity, which I have reason to believe deters many diffident persons from communicating their thoughts, thereby checking the progress of valuable inquiry. However, should the following pages be found to contain any new information on the subject, I shall feel happy in having communicated it; if not, I shall only have lost my labour, and I trust the public will not be injured by the attempt. The observations are intended not only for the consideration of those who construct carriages, but of the public in general; more particularly those concerned in the use of them, whose interests it considerably involves. In the sketches, explanatory of the following remarks, the reader will perceive I have avoided all the technical appurtenances possible, in order that their naked principle alone may appear more obvious.

I shall beg to commence by briefly stating the difference between a fly wheel and that of a carriage. This forms part of an answer to a favourite opinion of the late Mr. Charles Thellison of the city.

REMARKS

ON

WHEEL CARRIAGES.

A CARRIAGE wheel differs from a fly wheel, in as much as the former, when in action, is continually with its axis changing its place, while the latter revolves round a fixed point. The former is moved by a power (its axis) in the centre being pulled forward in a straight line, parallel to the ground, at the same time pressing almost perpendicularly downwards.

The lower part of the iron-box in a carriage wheel I consider to be the upper end of a perpendicular lever, and that part of the rim of the wheel which is exactly perpendicular to the box, the other end of the same lever, which supports the whole weight of the carriage, and, from the circular form of the rim, bears continually on a point; therefore while the carriage is at rest, the wheels can have no motion, because the four centres of gravity (if I may so say) are directly over or perpendicular to the ground point on which the wheels bear; but the instant the force applied removes the weight, or centre, or under part of the arm from the bottom of the box, or that part exactly perpendicular to that point on which the wheels bear on the ground, the wheel begins to revolve, the point on the ground forming the fulcrum at one end of the before-considered lever, and the arm which is dragged by the horses the power at the other end of the said lever. The wheel itself being composed (or conceived to be so) of an infinite number of these levers or spokes, issuing from a centre in all directions towards the rim, the undermost, as the wheel revolves, always supporting the burden, which form a regular succession of moving supports to the carriage. It appears, then, the reason of the wheels turning on this moving axis is, because these centres of gravity of the carriage are being continually pulled forward, so as to overhang those points of the rims at the ground, on which the whole weight of the carriage wheels, &c. bear; therefore the weight carries round the wheels by its being taken off the centre, or ground point, by the horses.

I trust you will perceive with me, that the carriage forces the wheels round, or along, from which I conceive the wheels have not the least power of mechanically forcing the carriage forward, because, for instance, if a power be applied to a wheel at the rim end of the spokes (the arm of the axletree, on which the wheel revolves, and the box of the wheel being well polished and case-hardened) the wheel will revolve on the arm, without moving the carriage one inch.

As the wheel appears to be only a convenient vehicle for facilitating the progress of the carriage, from its being a circle, the centre or box of which supplying at all times a smooth road, lubricated with oil, to reduce friction; it may be considered nothing more than a modification of the sledge, the box being the accompanying smooth road to the bearings of the journeying carriage. (See Plate 1, Fig. 1. A represents the box, B the axle, or supposed gravity, acting freely within the same, which is the origin of motion to the wheel.) The boxes of the wheels in all the examples are represented very large, and the axles, supposed to bear considerable weight, very small, that the action of their gravity may be conceived more clearly, and which in the carriage are always bearing hard upon the lower part of them; consequently it follows, that the greater perfection attained in hardening, smoothing, &c. the box and arm, the more adhesion or friction will be overcome, and the less will be the draught.

If, then, it appears the wheels do not force the carriage along, but the carriage the wheels, I think it follows, that the lighter they are the lighter the carriage will follow.

In opposition to this opinion, some people argue, that the heavier the rim and tyre of wheels are, the lighter the draught, forming their opinion from the accelerated motion of the fly wheel, which has no resistance at its edge. In support of this opinion, they say, take two small wheels, the one with a heavy rim, the other with a light one, and project them from your hand with equal force along the ground, that with the heavier rim will roll the farthest; not considering that these have no resistance to overcome in their centres, but only that on the ground, and that the impetus given to them is at the rim; by which the heavier acts as an additional power to the upper end of a common lever, thereby enabling it to overcome the resistance with greater facility at its fulcrum, and which is the cause of its superiority. But this is not a fair position, as bearing no analogy to a carriage wheel; for the power to the lever is transferred from the centre (as in the carriage wheel, it is the moving power to, and also a principal resistance to be overcome by, the wheels) to the rim, which being twice the distance from its only resistance, its fulcrum, the ground, and unincumbered by any central burthen, must roll a great distance with little force; and, so long as the momentum continues superior to the resistance, it will revolve.

Now a carriage may, by the increase of its momentum, increase the velocity of the wheels, but the wheels never can add any velocity to the carriage, because there is a constant resistance at the rim on the ground, thereby retarding all acceleration; which rim, to have an accelerated motion within itself, or from its own inertia, must be entirely free and unobstructed.

The wheels derive their motion from the gravity of the carriage being displaced from that point perpendicular to the one where they touch the ground (being brought forward by the mediate power of the horses, according to their speed): therefore, as it appears the wheels are continually pressed round by the weight of the carriage, and there is a resistance to the velocity at the ground, or its rim, and their moving power in their centre, I think it follows, that the more weight is added to the extremity of the wheel, the more is added to the resisting cause. As we perceive the rim is carried round by a power in its centre, and not that power or weight forced along by the rim, and that the whole or relative weight, is forced forward by this central weight, or power, it must inevitably follow, that the less absolute weight is in the rim, being so far removed from its evident source of motion, and deprived of the power of acceleration, the lighter the carriage must run. (For the relative situation of the gravity of a carriage, in the boxes of wheels at rest and in motion, see Fig. 2. A, situation of weight when carriage is at rest; B, situation of ditto, when in motion; C, line of gravity at rest; D, line of ditto in motion; E, line of draught.) The resistance is alwsys greater than the velocity; for how fast soever horses may travel, yet, on a level road, they have still some weight to pull. Further, to prove that wheels have no accelerated motion, more than is imparted to them by the velocity of the weight in their centres, through the increased speed of the horses, with which they keep up a corresponding velocity, increasing and decreasing agreeably to their pace, let us for a mo-

Fig. 1

Pl. 1

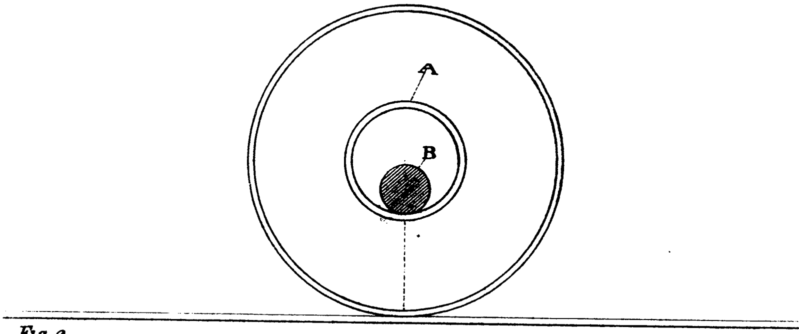


Fig 2

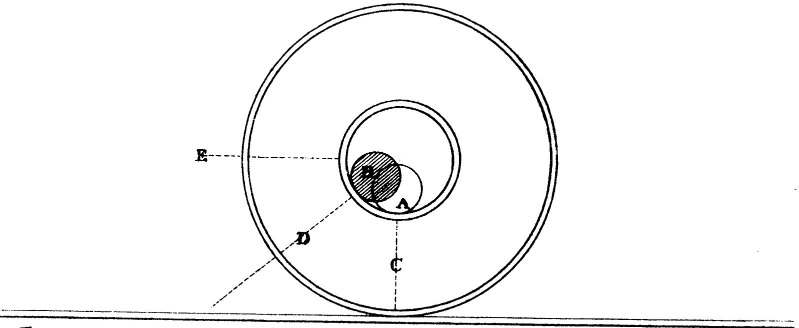
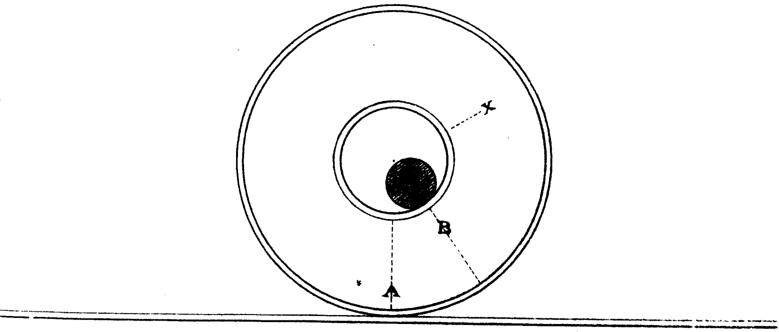


Fig. 3



ment suppose it to be the case, and that the momentum of the wheels does become superior to that of the carriage, the horses, instead of having any weight to draw, would not be able to stem its velocity, which has not ever yet (on level road, to which this reasoning refers) been found to be the case; for then the box, X (Fig. 3.), of the wheel would press against the back part of the axis, O, taking its purchase at A, and forcing against the arm at B, which is contrary to all experience on the subject.

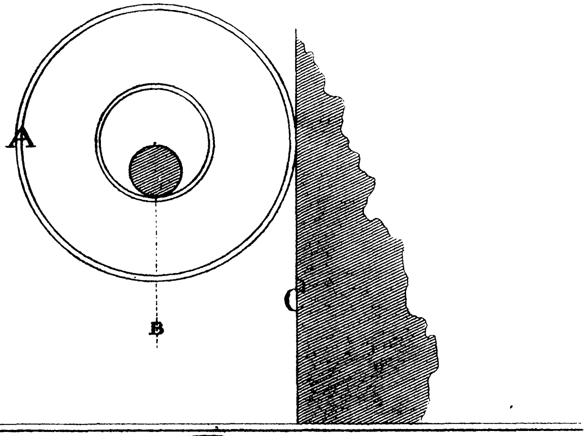
These observations lead me to consider the properties of the wheel in facilitating draught, and the advantages or disadvantages of their construction. First, I believe it is generally allowed, that if bodies once put in motion were not to receive any impediments in their progress, they would continue to move so for ever. Secondly, that falling bodies through empty space become so accelerated that the spaces descended from rest are directly proportionate to the squares of the times, till their velocity defies all calculation. Falling bodies, then, requiring no extrinsic aid to move them, I shall consider the subject I am about to inquire into, a great deal in reference to them, conceiving that the nearer a machine can be brought to act of itself, the greater will be the advantages derived from it.

First, it must be recollected, that I endeavoured to prove, that the carriage wheels derived their motion from its weight. Now, as all gravity takes a perpendicular direction, consequently the more a road is inclined to the natural line or direction of all gravity, the more easily a body on such road will move of its own accord. For Ex. (See Fig. 4.) suppose C to be an almost perpendicular road; A, wheel on ditto; B, the gravity of the carriage, seen freely acting within the box, and impelling the wheel's descent. It may easily be conceived to require no extrinsic aid to give it motion. Reduce this perpendicular to a slightly inclined plane, we find this plane (See Fig. 5.) takes a portion of this gravity at B (that proportion to the whole weight which the segment, D, bears to the size of the wheel, while the line of gravity cuts the plane at C), which gravity was before entirely within itself. (See Fig. 4.) In reducing this plane to several gradations of inclination (as Fig. 6 and 7.), we find the natural situation of this gravity in a state of rest, on the level road. (Fig. 8.) Now, to give motion to a carriage on this level road, we require extrinsic, or foreign aid, as a substitute for that intrinsic force, or gravity, which gives it motion on an inclined plane.

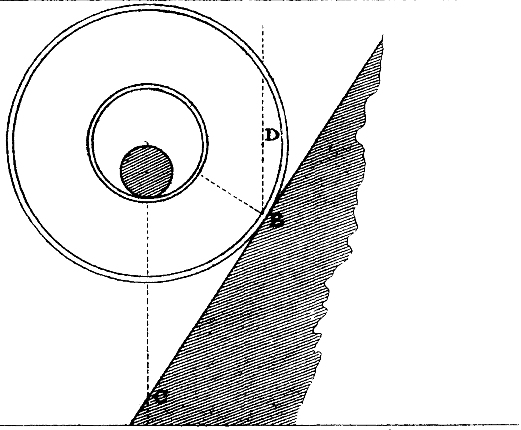
As we find motion is to be derived from gravity alone, the more the gravity of a carriage, by any contrivance, can be brought in to assist the moving power, by causing the natural line of gravity to take the direction of the line of draught, the more the carriage will be impelled along by its own intrinsic force, and, consequently, requires less power. (See Fig. 9.) By this, we see the more the line B, or gravity, takes the direction of C, the more it is brought to assist the draught. (See Fig. 7, 6, 5, 4, &c.)

Having stated the manner in which motion is immediately conveyed to wheels, and that the forwarder the line of gravity can be thrown, the less power will be required, I have to inquire, what wheels, and whether high or low ones, are most conducive to answer that end; and what advantages or disadvantages are connected with the present construction. In order to ascertain, whether high or low wheels are most advantageous, which has been a subject of so much controversy; let us suppose two carriages running down a hill, (see Fig. 10 and 11); the centre of gravity in each the same height from the ground. We find, on comparing these two examples, whose weight is supposed to be the same, length of perch in both equal, but the wheels of the lower twice the height of the upper one, and in comparing the centres of gravity of the

Fig. 4



ig. 5



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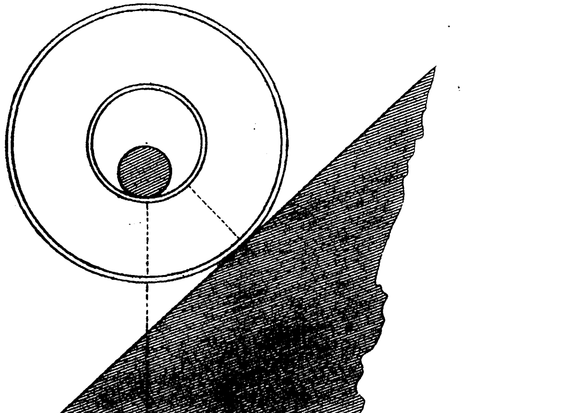


Fig. 7

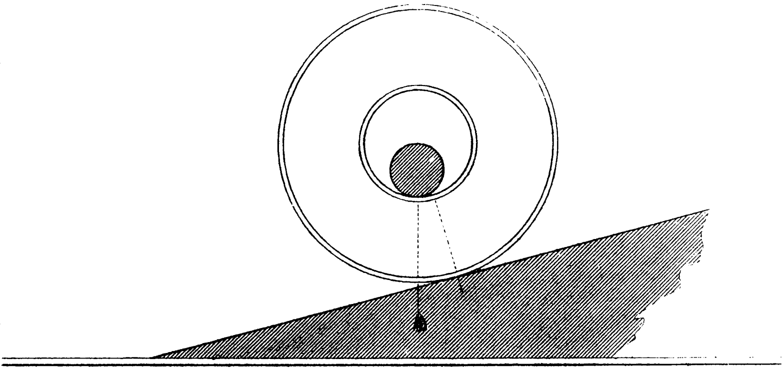


Fig. 8

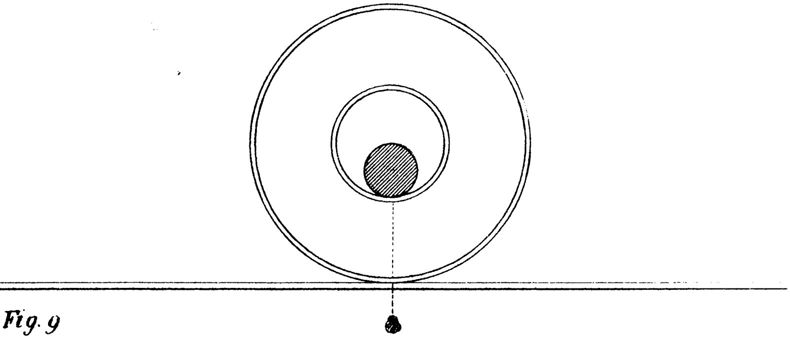


Fig. 9

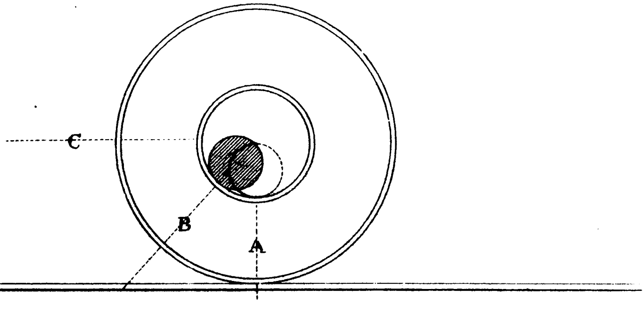


Fig. 10

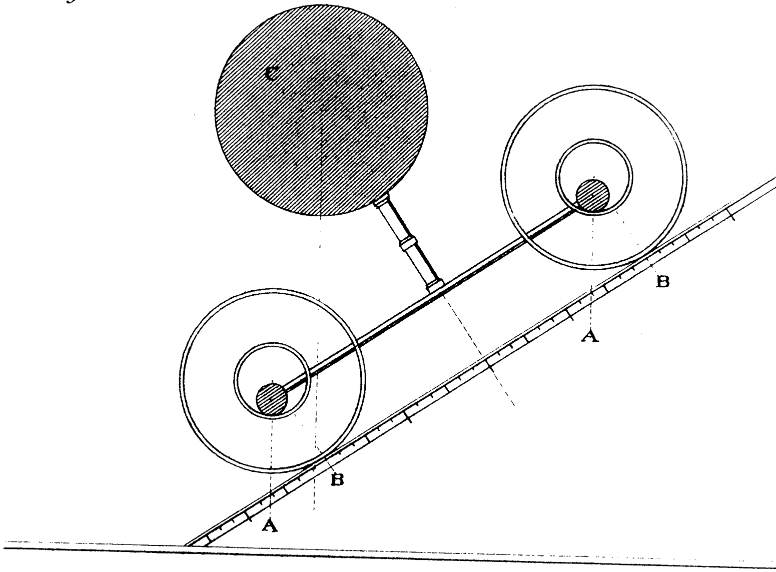
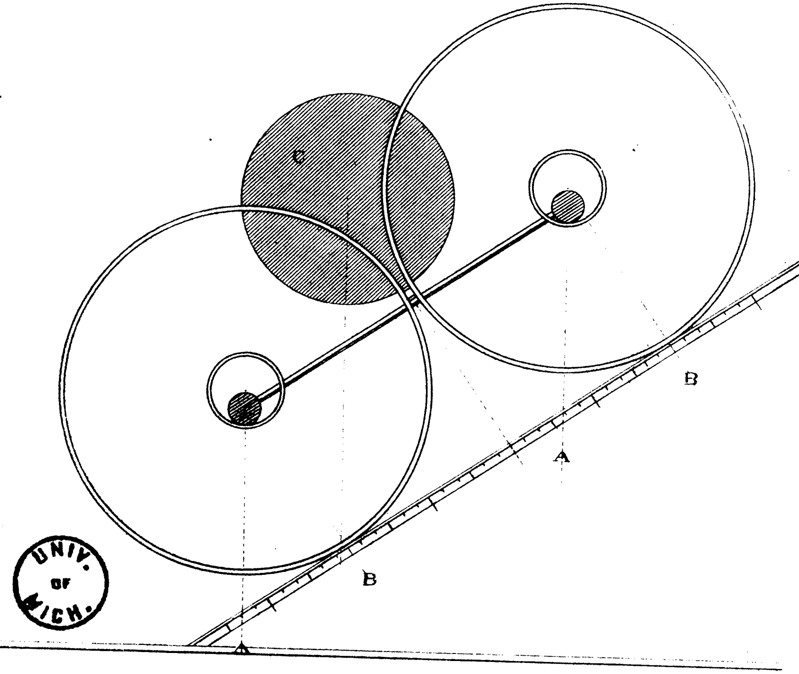


Fig. 11



wheels, agreeably to my former observations, we find that the centres of gravity A, on that with the higher wheels, are double the distance of the corresponding letter in that with the lower wheels from the letter B, or centre of gravity of both, when in a state of rest on the level plane. As it is found that this line falls twice the distance from the point B, where the wheels bear, it is a proof (I think sufficiently convincing) of its having double the power, and, consequently, will move down the hill with double the velocity!

I now proceed to apply this reasoning, with respect to the descent of carriages on inclined planes, to the draught on level road, and shall endeavour to point out the best sort of wheel, and the nature of the friction on axles and boxes, together with some observations on long and short carriages.

I before observed, we might consider the power of horses, applied to carriages on a level road, as a substitute for, and in the absence of that propelling power or gravity, exerted in the descent of carriages on inclined planes.

We are, then, under the necessity of devising the best means of compensating for the absence of such gravity, which imparted motion on the inclined plane, but which induces a state of rest on the level.

I shall now consider, that the horses are the extrinsic power applied as a substitute for that intrinsic force, which before was the moving power, but now the weight to be moved, continually counteracting, instead of facilitating, the progress of the carriage. Now, as we found in the former examples, that the more the plane, or road, is inclined to the perpendicular, the more the gravity is inclined to the parallel of that road, or plane, (see Fig. 6, 5, 4), consequently the more the gravity of a carriage (which on a level road, and in a state of rest, is at right angles with that road or plane) can be brought, by mechanical contrivance, to take a parallel direction with the road, so much more of that gravity is brought in to the assistance of the extrinsic aid, or moving power, the horses, (example, Fig. 12, 13, 14). Here we see clearly that which is the cause of motion on the inclined plane c c (Fig. 12), is the very cause of resistance on the level (Fig. 14), and we must not forget that this high construction of wheel, which tends to facilitate the progress of a carriage, in a descent, will not, as has been frequently urged, under proper arrangement of weight, operate to a proportionate disadvantage up hill; on the contrary, I maintain, that that construction of wheel which facilitates the progress of the carriage on either a level plain, or descent, that facility is not lessened in any situation. I shall have occasion to speak further on this in its proper place; therefore, the more the line of gravity A (Fig. 14), is brought into that of B, the less extrinsic aid it will require.

I come now to the consideration of the advantages or disadvantages of high and low wheels, with respect to level roads. In doing which, I shall suppose three two-wheel carriages (represented by Fig. 15, 16, and 17), of equal weight, placed on a level road, the wheel of each higher than the other, and the centre of the middle sized one, the height of the line of draught, and the power, or horses, represented by the balls x, each the same distance from the burden, the boxes of the wheels of an equal size, in each which are here represented very large in proportion to the wheels, the axles very small, done as before to give a clearer idea of their action within the said box, these axles, or supposed gravity, when in motion, takes the diagonal direction, and the obliquity of that direction is exactly according to the force applied, and that force always corresponds to a certain inclination of plane; that is to say, the horse must exert as much power to bring the line of gravity into the line of o, (see Fig. 15), as is equal to the force of gravity, caused by the exact inclination of the hill, or plane c, to the level. Or if the force of gravity, on such inclined plane c, is 50lbs.

Fig. 12

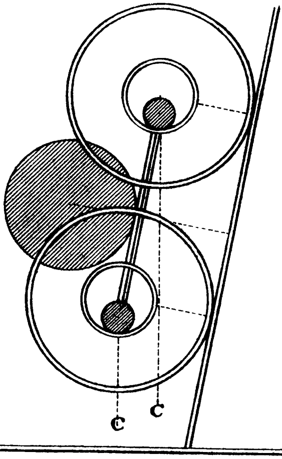


Fig. 13

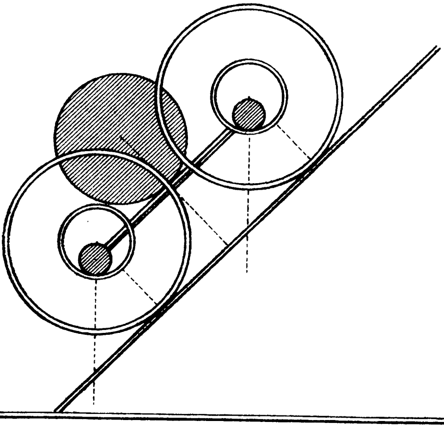


Fig. 14

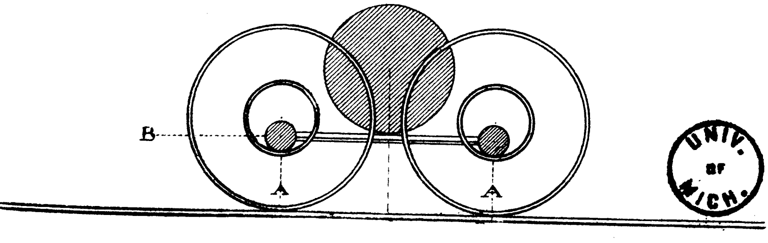


Fig. 18.

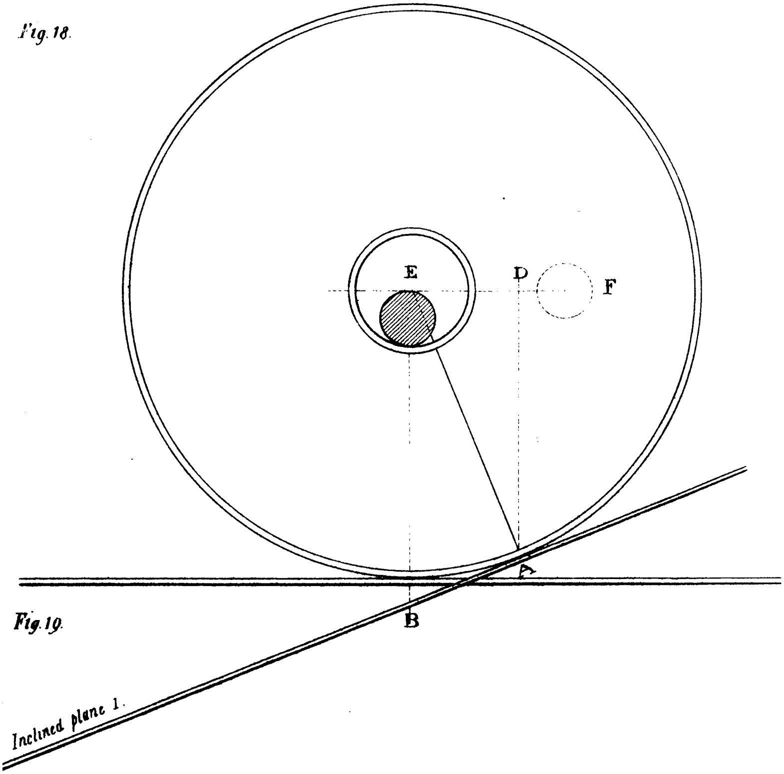
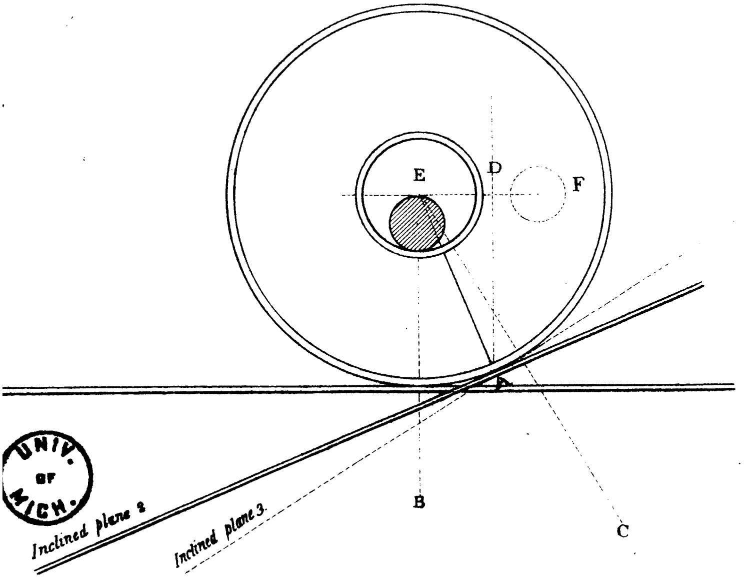

E
D
F
A
B
Inclined plane 1.

Fig. 19.


E
D
F
A
B
C
Inclined plane 2
Inclined plane 3.

the horse, to give to the carriage equal velocity, on level road, must pull with a power equal to 50lbs. for we may perceive the point D, in the inclined plane from A on ditto, is the same distance as the point F from the point B, which, being thrown as far again from its line of resistance F, as B from F in Fig. 17, must of necessity lead us to conclude that the burden on that sized wheel will be moved with, at least, half the power required for wheel, Fig. 17. Now, to prove the increase of power by high wheels, suppose the ball in the upper wheel to press with a force equal to 50lbs. I find the line of gravity B (see Fig. 18 and 19), cuts the inclined plane 1, 6⅓ tenths of an inch from A, the fulcrum of the wheel, or where it bears on the ground (this point and the centre of the wheel being always at right angles with the plane on which it runs). Suppose, now, the ball on the lower, or small wheel, to press with an equal force (in respect to itself) or 50lbs. (the plane of the same inclination as the upper one). I find the line of gravity B cuts the inclined plane 2 only 4-tenths of an inch from A, the fulcrum or bearing point of the small wheel; therefore, instead of rolling down the plain with a velocity of 50lbs. it only rolls down in the proportion to 50 (as 4-tenths is to 6-tenths) that is, with a force of about 34lbs. and in order to impart to the small wheel the velocity of the high one, the plane must be more inclined to the perpendicular, as the inclined plane 3, where we find the line of gravity B cuts that plane at the same distance from its corresponding fulcrum, cut by the dotted line C, as line B cuts inclined plane 1 (Fig. 18); therefore requiring a power, on level road, to move the weight on this small wheel, with the same facility as on the high one, as much above 50lbs. as 34 is under 50, that is, 16lbs. making 66lbs. instead of 50; further, to prove this to be on the principle of the common lever, or steel-yard, let it raise a perpendicular from A, the fulcrum of the wheels, and intersect it at right angles at the centre of each wheel, we may perceive it completely forms the principle of the common steel-yard. F, the weight, D, the fulcrum, and E, the power: here we find the weight in the large wheel is further removed from its fulcrum than that in the small one in the same proportion as the line of gravity fell on the planes.

As the horse, the extrinsic power on a level plane, is substituted for that intrinsic force exerted on an inclined plane, I trust you will perceive he does nothing but pull that gravity forward (over the fulcrum of the wheels on level road) which hangs over the said fulcrums on the inclined planes, and by drawing a line from this fulcrum, always parallel to this direction, we precisely find how much of the gravity of the wheel itself is brought into action, (see Fig. 20 and 21). A, the line of gravity at rest on level plane; B, line of ditto in motion, pulled forward by as much extrinsic force on a level as is exerted by the gravity B down the inclined plane X; O, the line parallel to that of gravity, shewing how much of the gravity portion of the wheel itself is brought into action, so that the greater the inclination of the plane, or the faster the speed on level road, the more this gravity of the wheel itself, and its burden are brought in assistance of the draught.

Now, as it appears that the higher wheels are the more they throw the gravity forwarder than the lower ones, by the application of the same force, it will, no doubt, be acknowledged carriages must follow lighter for them. (See a further elucidation, page 26.)

It appears to me, from the present construction of carriages, that considerable disadvantages arise from elevating the weight above the axle-trees, for the higher the weight is, the more it tends to press the fore wheels into the ground, and to relieve the hind ones, capable of taking the greatest weight, by which the roads act as a continual hill, which added to the disadvantage of their size, causes excessive draught, while the hind ones have, in comparison,

Fig. 20

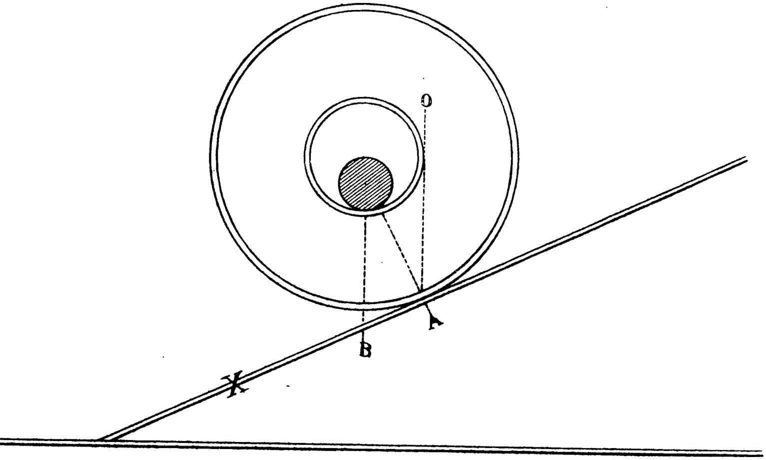


Fig. 21

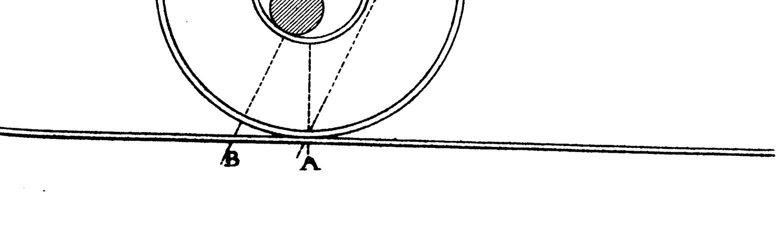


Fig. 22

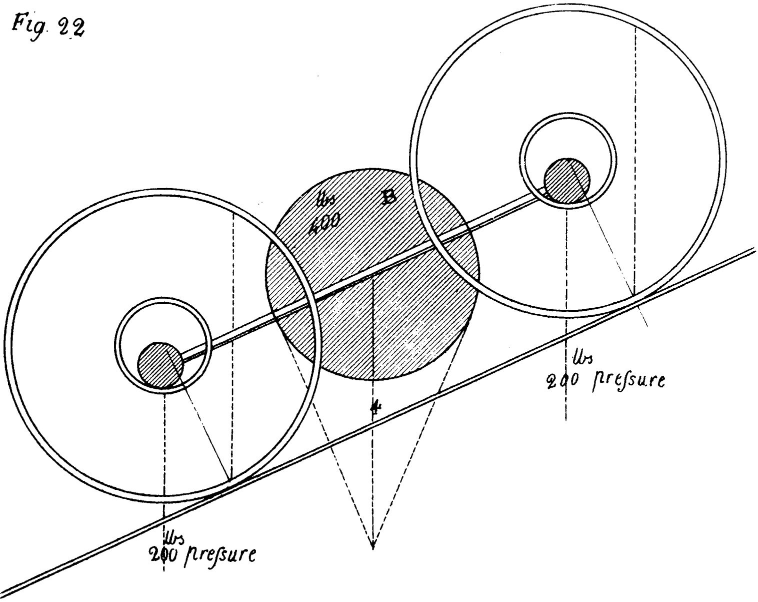
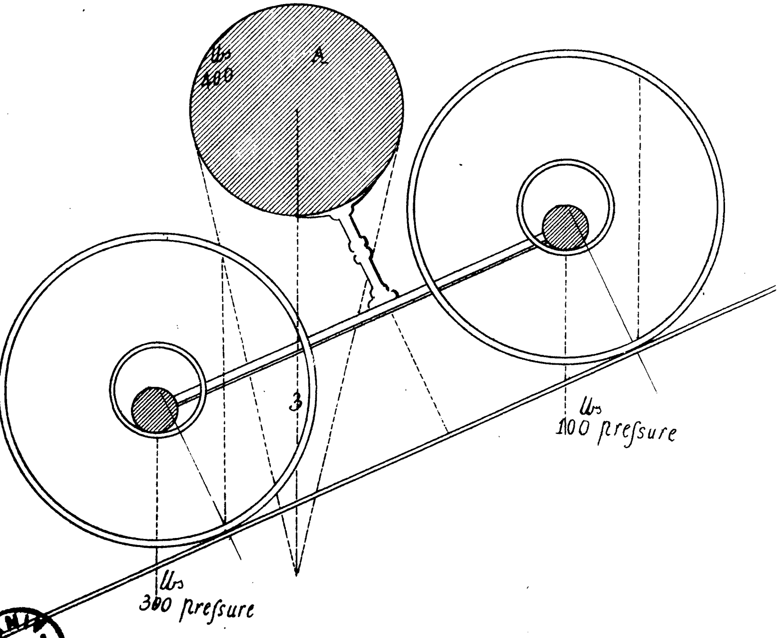

lbs
400
B
4
lbs
200 preſsure
lbs
200 preſsure

Fig. 23


lbs
400
A
3
lbs
100 preſsure
lbs
300 preſsure

nothing to do. (See Fig. 22 and 23), Fig. 23 representing a simple carriage (the wheels of equal height) the axle-trees connected by a simple perch, supporting a solid ball, of a given weight, rolling down a hill of a certain inclination. On inspection, we find the centre of gravity, line 3, cuts the hill 1-fourth nearer to the fore wheels than the line 4, in the upper example (Fig. 22). Supposing both weights, 400lbs. as the elevated weight presses ¼ nearer than the other 100lbs. are transferred from the hind to the fore ones, which, consequently, carry 300lbs. and the hind ones only 100lbs. because in Example 22, the line of gravity falling exactly between the hind and fore wheels, each end carries 200lbs. Applying the principle of extrinsic force, before laid down, concerning carriages put in motion on level planes; by this force, we find the same disadvantage results, these observations are deduced from wheels of equal weight, but, when applied to carriages with smaller wheels before than behind, the disadvantage is increased in proportion to the smallness of them; so that, if small fore wheels must be used, the weight ought to be brought so much nearer to the hind ones, that the line of gravity may fall in the same proportion nearer to the hind wheels as the fore ones are less in the proportion to them (example, Fig. 24); this hind wheel is $\frac{1}{3}$ higher than the fore; consequently, the weight must be placed $\frac{1}{3}$ nearer, in order that they may bear equally on the ground, then the fore one cannot press more into soft ground than the other. Here we find, that by moving the weight on the perch (in the proportion to its length) nearer to the hind part as much as the hind exceeds the height of the fore wheel, we do away the disadvantage of the smallness of the fore wheel, in this respect, by causing an equal pressure, and render the following of the carriage as light as though the hind and fore wheels were each of the mean height of both, with the weight centrically placed. From these last observations, I think

I may conclude the most scrupulous nicety ought to be observed in placing the weight in such a situation, on four-wheeled carriages, that each wheel, if of equal height, should bear an equal proportion of weight; but, if the fore are smaller than the hind ones, the observations on Fig. 24, must be adhered to.

Having shewn somewhat of the nature of draught (of which I shall have occasion to speak further), and having given some reasons for the proper situation of weight on carriages, I shall endeavour to shew the disadvantages attending inclined arms of axle-trees and dished wheels, and make a few observations on the nature of friction, as it respects the boxes of wheels. First, it is proper to inform all those at present unacquainted with it, that in all dished wheels, or such as have the nave sunk considerably within or lower than the outside of their rims, the tyre edge or rim forms the frustum of a cone, whose point lies outward, and lying on its side, its base towards the carriage, the natural motion of which is forming a circle round its point, A (See Fig. 25.); this wheel in the example is dished more than common, in order to see the nature of it more clearly. The arm, A, of the axle, B, is turned down, according to custom, so as to bring the under spoke, C, of the wheel when on perpendicular (which must be the case, to make it bear even on its sole, or tyre), to support the weight. The rim, or tyre, is represented very wide, from which it will be seen how decidedly it partakes of the figure of the cone, of which it certainly is but a section. I observed that the natural motion of the cone, situated as above described, was its base moving round its point, describing the circle, CCC, &c. (See Fig. 26.)

It may be seen each part towards the point describes a space proportioned to its circumference, making its own centre at a; but in applying this principle to the wheel, we are to recollect that

Fig 24

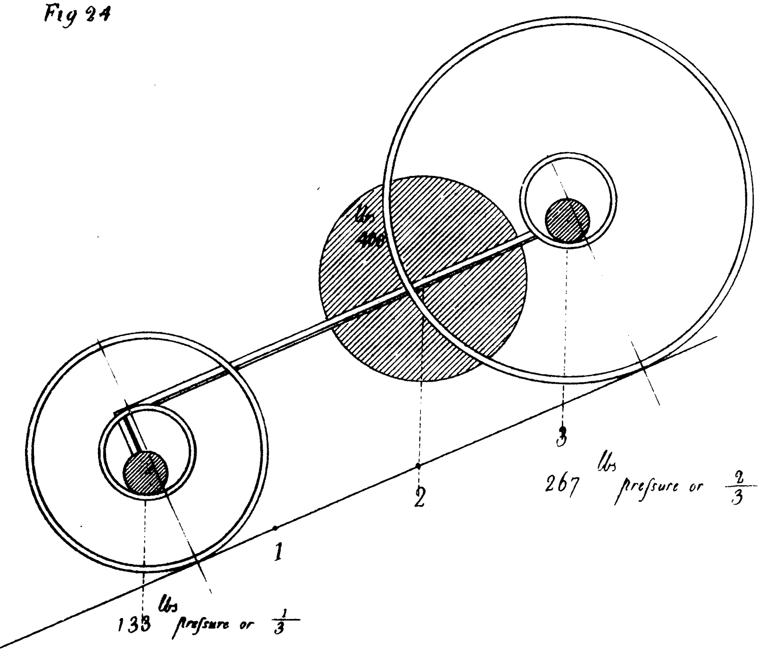


Fig. 25

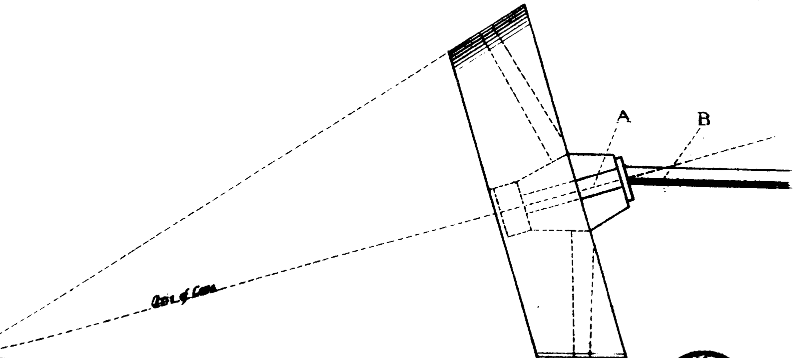
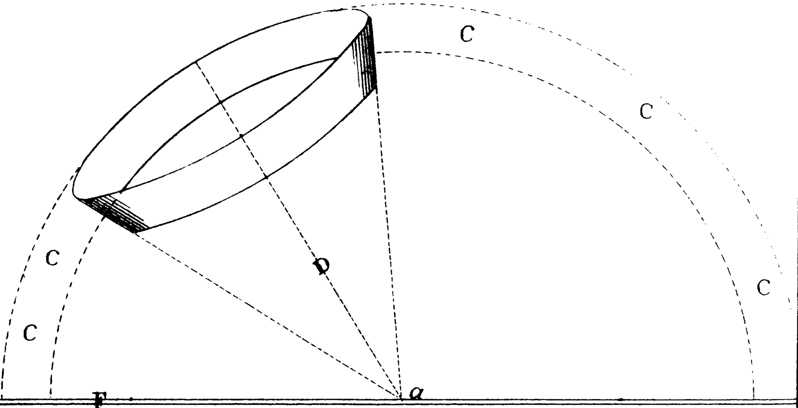


Fig 26



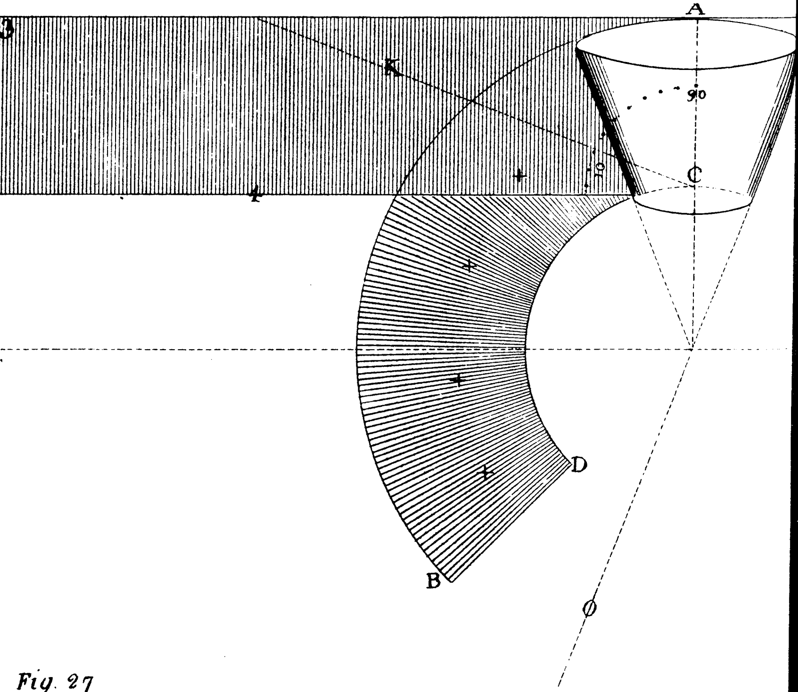


Fig. 27

the axis is always at right angles with the line F, while the axis of this cone is continually varying its situation in respect of this line. Now, as we know that a small circle cannot describe the same space in one revolution that a large one will, it is natural to conclude, that if the edge of a wheel is composed of circles varying in size, they cannot follow together in a straight path. (See Fig. 27.) Here we see the small circle described in the centre of the figure cannot get over the same space in one revolution as the larger one at its base. The circle at the base in one revolution describes the space contained in the arc from A to B, which marked off on the road, line 3, would describe a space from A to 3. We find likewise that the circle towards the middle of the cone, which is half the size, would describe in one revolution the space contained in the arc from C to D, which marked off on the road line 4, parallel to 3, would describe a space from C to 4, which is only half the space of the other; therefore, if we require this small wheel to describe the same space as the large one in one revolution, and in the same time, and on the same axis, it will have to be dragged in the direction of the line k (with a power and velocity sufficient to make the remaining distance in the same time), which is precisely at right angles with the diagonal side line, o, of the figure. This diagonal friction on the ground is the sole cause of the outside part of the tyres of wheels wearing thinner than the inside, because the more the outside approaches to the point of its cone, the greater this drag; and it is this unnatural action alone which breaks the pebbles in the road, instead of burying them, and acts to all intents and purposes the same as a plough. To calculate the resistance of this side drag, let us suppose the broad conical wheel, or roller, A (Fig. 27.), to be rolled round in its natural path or direction, by a power of 20lbs. and suppose it would take a power of 90lbs. (which we will consider as degrees, or the ¼ of a great circle) to drag it on the ground at right angles to its line of revolution, the line of friction or resistance K to the small end of this broad conical wheel being at the angle of 21 degrees (supposing 90 to be at A), it would require 21lbs. in addition to the 20, to pull this conical wheel along in the direction of the broad road contained between the lines 3 and 4, which may be considered to be the measure of the friction. From the foregoing observations we may perceive the disadvantages resulting from this construction of wheel, for whatever may be the weight, this side drag is in the same proportion, that is, whatever power it would require to drag the whole carriage and weight sideways, this side drag is to that, according as the wheel is dished more or less, as 20 to 90 degrees, or nearly ¼th. (but we must recollect this calculation is supposed to be with this excessively dished or conical wheel, for it is proportionably less, the less conical the wheel is) to be added to this is the immense pressure of the wheel's nave against the nut of the axle, alone occasioned by this side drag on the ground. Now, in straight arms of axles, with perfectly upright wheels, these glaring defects are entirely done away, and the only unavoidable resistance remains, viz. that at the bottom of the arm: which leads me to consider the best means of lessening this resistance or friction, to effect which, as much as possible, is a very important object.

I think I have determined, that weight is much more easily moved by high than by low wheels, or rollers, and have considered the box of the wheel merely a modification of the sledge, or an accompanying smooth road for the arm to slide on. As the iron-box is continually rubbing against the arm in an opposite direction, the smoother these two bodies can be made, the less adhesion they are liable to. We may all have observed the facility with which heavy timber can be moved over the ground by shifting rollers, and the nearer we apply this principle, by introducing a medium approximating as much as possible to it, the more we shall diminish this adhesion. We likewise find that the greater the specific gravity of any fluid is, the greater is its buoyant quality; and, consequently, does not become so much pressed as a lighter fluid by an equal weight. From these two principles must be deduced the practice of introducing oil to axles, and, from the last, the greater the specific gravity of oil, the less its particles (which may be considered globules or rollers) are compressed. Now as we find a number of rollers facilitate the moving of great weights, so the greater quantity of oil (the constituent parts of which being globules, or rollers) we can admit under the bearings of great pressure, the more easily it will be moved; therefore, instead of reducing (as is the present custom) the quantity of bearing, we should increase it in proportion to the weight. For example, take two large plates of plate glass, oil their surfaces with pure oil, and lay the one flat upon the other; then take another plate, lay it flat, oil the surface; and place another, the size of the uppermost, edgeways upon it, and you will find the one lying flat will be moved by the $\frac{3}{4}$ parts of the power required to move the one lying upon its edge. This proves the advantage derived from the quantity of medium introduced between the surfaces; for, if tried without the medium, both situations require the same power to move them in. Or, if we take two pieces of wood of equal size and weight, place them on a plate of smooth glass, one on its edge, the other on its side, they will be found to draw with equal ease; therefore it appears that weight presses in proportion to its quantity of bearing; but if we introduce rollers between the surfaces, this weight will be drawn with surprising facility, and the more rollers are introduced, the draught will be found to be proportionably less, or the more easily the weight will be drawn; consequently, being enabled to introduce a greater number of rollers under the broad surface than under the narrow one, it must, will, and does have considerably the advantage. Referring oil to this principle, we must recollect that the number of its particles, or globules, are compressed from under its burden in proportion as the weight is greater, and are liable to be entirely pressed out from between the surfaces by excessive pressure, by which its benefit is totally lost; and this is the more likely to occur, where the surfaces of bearing are exceeding small. Further to prove that a great deal of ease of draught depends upon this medium, we have only to try the quantity of friction by an experiment without it, which will shew us it is an essential ingredient in overcoming this species of resistance. If, then, it be allowed to be essential, being of a standard specific gravity, or quality, we must so contrive our machine as to combine all the advantages that this standard quality is capable of imparting. In a word, as its use is essential, and we cannot manufacture it agreeably to the power of our machine, we must manufacture our machine to it. From these few observations it seems to appear, that the best oil for these purposes is that of the greatest specific gravity, without any unctuous quality (therefore fat or rancid oils are unfit), but new castor oil appears eligible for these reasons.

As all inequalities in surfaces which have to glide over each other, tend to fix or fasten them, it follows, that the boxes of wheels and axle arms cannot be too smooth, hard, nor too highly polished, and, from the former observation, ought to have all the bearing possible, in order to combine the advantageous quality of the oil. The arms should be straight and cylindrical, for reasons to be inferred from the remarks on the dished wheels. These last considerations lead me to apply the reasoning on large surfaces for axles to the quantity of bearing that wheels should have on the ground: and, as in carriages, we find they are subject to travel on roads of various quality, we should adapt them so as to be most easily moved on the very worst ones they can encounter (which no doubt are the softest), feeling assured that principle is sure to succeed on good ones. The first thing, let it be recollected, is that carriages meet with the greatest resistance up hill; therefore any construction which in itself tends to promote this sort of resistance ought to be avoided, and that which offers a remedy encouraged. There is scarcely any one but has observed the facility with which horses draw their burden when the roads are hard, and who have not likewise witnessed the increase of exertion required to draw the same burden when the roads are bad (as they are termed), or soft. The reason is very obvious, the sinking of the wheels, which are continually in a hole, from the great pressure: the dirt in front of the wheel forming a continual block, or resistance, and which to all intents and purposes is the same as a continual hill. The sinking of the wheel, then, being the cause of this increased resistance, we must endeavour to find a remedy (and as it cannot be found in the road, it must be found in the wheel), which indeed nature herself seems to point out, by bidding us contemplate the feet of such animals as she has destined to tread on soft soils.

Let us, then, imitate so unerring a guide, and destroy this burying principle of the wheel now in use, by adopting broad tyres, which, together with upright wheels, would entirely do away this sinking (not forgetting, but like her, to proportion our breadth to our weight), particularly when we contemplate their general use to all descriptions of carriages, by which the roads throughout the kingdom, even in the rainiest season, would be hard, and free from ruts, like a garden walk. (This would be greatly assisted by the plan proposed by the ingenious Mr. Collinge, of making the road a perfect flat, and repairing it all over equally when wanted, instead of raising it in the middle, which not only tends to the overturning of carriages, but is avoided by every driver, to the great detriment of the sides.) Adding to this the immense saving, by their keeping the roads in constant repair, their adoption would, in my humble opinion, turn out of the greatest public advantage.

Having, in the last section, finished the questions therein proposed to be discussed, I intend in the following one to offer a few considerations on the subject of long and short carriages, the nature of draught, or direction of the line of traction; together with some remarks on the relative weight of wheels to their burden, by the increase of their height, which will involve some further considerations on that and their properties. First, then, of long and short carriages;—from which arises the greatest advantage in point of carrying burdens? In order to consider this question fairly, we should conceive both carriages of equal weight; and, to give to understand more clearly, I shall be under the necessity of recapitulating some of my former observations, which, together with what I shall further adduce, I shall leave to the consideration of the candid, from whom I shall receive any hint on the subject with peculiar pleasure; at the same time begging them to receive my observations as the spontaneous suggestions of my mind (therefore liable to error), and a mere effort to assist in developing the certain principles of wheel carriages, and in dispelling that load of prejudice now in favour of the present system, which I have not the presumption to hope will yet be obliterated.

I shall now beg you to recollect again, that I considered horses as a mere extrinsic power, or substitute, employed in the absence of the inclined plane (or that intrinsic force occasioned thereby) to shift the line of gravity of the carriage forwards on level road; therefore I shall deduce my remarks from this principle, taking the angle of the line of gravity to the inclined plane for the angle of the

Fig. 28

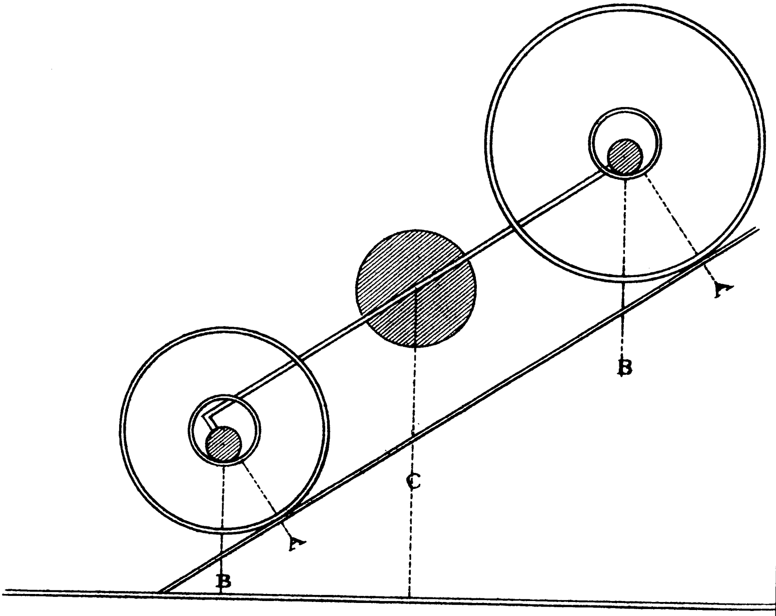
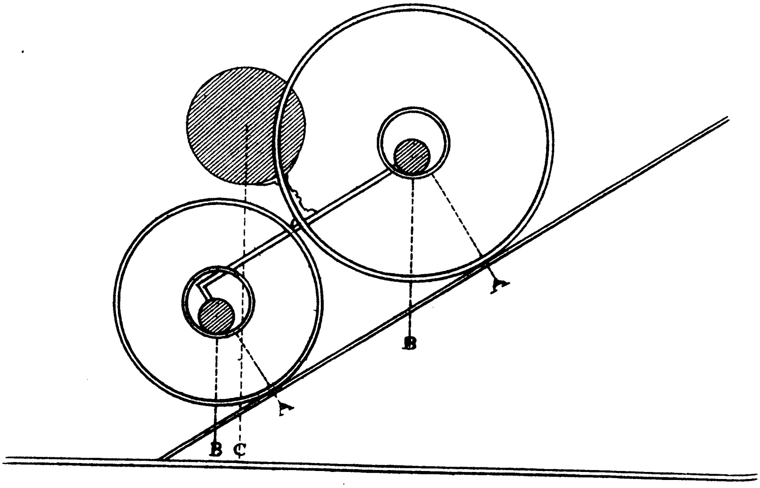


Fig. 29



line of gravity, pulled forward with respect to the level road. (Example, Fig. 28 and 29, represents two carriages, one short, the other long, of equal weight, and the wheels of the one the same height as those of the other, both situated on equally inclined planes; the weight on the short one risen just high enough to admit the 'fore wheel to lock, which must of necessity be the case.

On examining these figures, we find the centres of gravity, B, of the carriages, exerted in the box of the wheels, fall the same distance from the bearing point, A, of the wheels in the short as in the long one; consequently they must descend with equal velocity on planes of the same inclination, with perfectly hard surfaces; but if we presume a soft surface, applying the reasoning on Figures 22, 23, and 24, with reference to the line of gravity, C, between the wheels of the two examples, 28 and 29, we shall find that the shorter carriage gives to the line of gravity of the weight (which is precisely in the centre of each perch) a forwarder situation (caused by its elevation) than the other, thereby pressing with greater force on the smaller wheel, causing it to sink considerably more into the ground than the longer one, which certainly would considerably retard its velocity, giving to the longer one a decided preference. Therefore it is my humble opinion, that if the weight is to be placed in the same situation on each carriage with respect to the perch, and the carriages of the same absolute weight, that the longer carriage would follow, particularly in soft roads, infinitely the lighter. Consequently it appears it matters not of what length the perch of a carriage is, so long as actual weight is not increased; for its gravity will always find the same situation in the wheels, or rather boxes of the wheels, of each, whether short or long, and as there are but four bearings for the weight, it matters not how far they are asunder, (with the foregoing proviso), for it cannot bear any analogy to a line with a weight affixed, dragged along the ground, for there every additional inch yields a proportionate degree of resistance, from the friction against the earth. If, then, this appears to be the fact, and coupling it with the remarks upon the situation of the weight, both as to height and between the wheels, I think we cannot help perceiving the absurdity of the present construction of stage coaches, in which appears to be combined every arrangement to endanger the lives of passengers, to fatigue the horses, and cut up the roads. In the first place the shortness of their carriages (see Fig. 29), causes almost the whole of their weight to be pulled over the fore-wheels, which is more and more so, the faster they travel, thereby giving the hind end a tendency to kick up, the hind wheels scarcely bearing any weight, (in comparison to the 'fore ones) one of which receiving a sudden jerk, or elevation, from a stone or other inequality in the road, naturally and suddenly throws the centre of gravity over the opposite fore wheel, by which the stage coach is consequently overturned. This evil of the short carriages is doubly increased by the high loading; thus are the lives of the passengers endangered. From the before-mentioned cause (the weight being pulled forward) the fore wheels are pressed so forcibly into the ground, particularly in bad weather, that they are in a continual hole, while the hind ones, capable of taking the greatest weight, has the least; which, added to the immense friction from dished wheels, before explained: together with the present favourite system of curtailing their height, and of oblique traction, nearly doubles the draught. Thus are the horses punished, whose latent strength, forced out by the application of the whip, are soon rendered fit only for the dogs. From one of the last-mentioned causes (dished wheels), comes the almost, I may say, impassable state of the roads, for each pebble which should tend to harden and consolidate the road, is broken, pulverized, and at last reduced to little else than clay, which being

Fig. 30

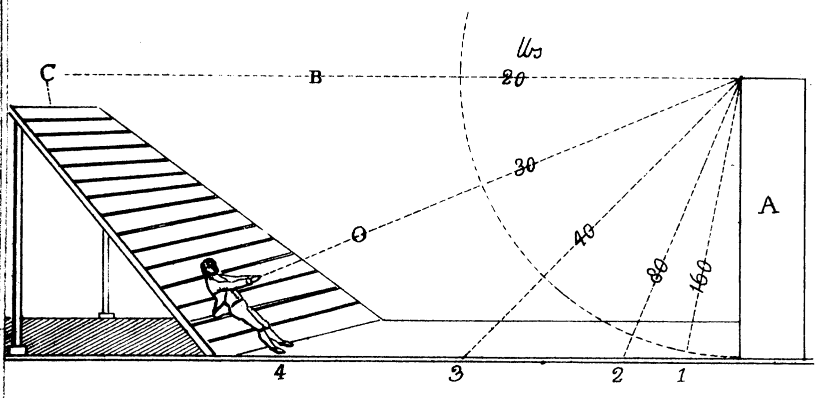
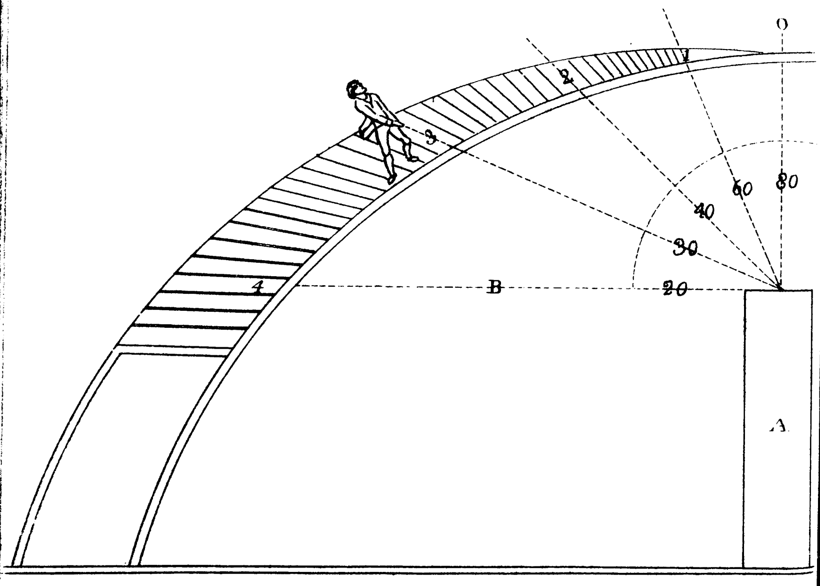


Fig. 31



again acted on by the same destructive cause, is absolutely ploughed up into furrows, like a ploughed field ; thus are the roads injured.

I shall now offer some remarks on the nature of draught, which will lead me to a further explanation, and a more particular elucidation, on the size of wheels, together with some observations on their weight, and the burden they carry, wherein I shall endeavour to prove, that high wheels facilitate draught in a surprising degree the higher they are, and that the consequent additional weight is no material drawback; but, at the same time, the lighter they are, the greater will be the advantage, provided the height is not sacrificed to obtain it.

In the first place, I beg to lay it down as a general rule, that, whatever may be the height of the wheel, the draught line, to move it with the greatest facility, must be from its centre, parallel to the plane on which it moves. In order to make this clear, I beg attention to the following remarks, which are, in a great measure, recapitulary of my first setting out. For example; suppose you wanted to pull down the pillar A, (see Fig. 30), of a certain height, say three times as high as yourself, standing upon its base; of course, you would place the rope round its top. Suppose you were not capable of exerting a power greater than 20lbs. and that it required just 20lbs. to effect its overthrow in the line B, and that you were to commence your exertion at the stand 1, at which place you would find it immovable: now, if you tried your strength at the several stations 2, 3, 4, you still would not be able to effect it; but, if you ascended the platform C, until your rope came into the direction of B, then your exertion would be effectual, and the pillar would fall. Now, the reason your exertions were unavailing below the line B, was because the rope gradually fell into the line of the pillar itself, by which it is pulled more firmly to its base, for it takes 30lbs. to pull it down in the line O, 40 in line 3, 80lbs. in line 2, and 160lbs. in line 1, &c.

Now, supposing you had to pull it down from a situation which would not admit you lower than the top of the pillar (see Fig. 31), but as much higher as you pleased; and that you could exert no greater force than before, and that 20lbs. would pull down the pillar exerted in line B, the pillar itself weighing 80lbs. you would find you could not effect your object in any situation, but at 4, is (taking 30lbs. at 3, 40lbs. at 2, 60lbs. at 1), because, the higher you rise, the more of the absolute weight of the pillar must be taken, as at O, 80lbs. would lift it from off the ground.

This reasoning will apply fully to a wheel, the under spoke constituting the pillar, the top of which, the box, or centre of the wheel, the horse the power, if the line of draught is under the centre, he pulls against the ground, if above a portion of the absolute weight.

Although it appears, from the preceding examples, that the purchase below, the central line is considerably the more disadvantageous of the two, and therefore, at first sight, seems to counteract my former reasoning, in respect to high wheels; still in the conclusion, it could not be found so. My object, in these two examples, was merely to prove, that with respect to wheels, whatever their height, the line of draught ought to be parallel with the centre, which I trust I have done.

I have, in a former part, determined high wheels to have the advantage, deducing that advantage from the descent of carriages on inclined planes, the gravity of the carriage always acting on the centre of the wheels, whatever may be their height, from which, and the last observations, I think I may venture to assert, that whatever may be the weight, and whether placed on high or low wheels, the line of draught, to move that weight the easiest must be parallel to the centre of the wheel; therefore, we ought strictly to avoid that oblique line of traction so very prevalent, and, indeed, so absurd, and attach

Fig. 32

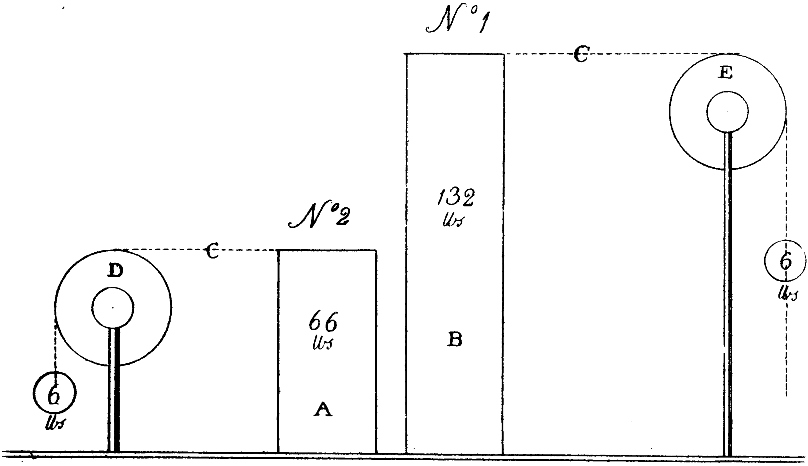
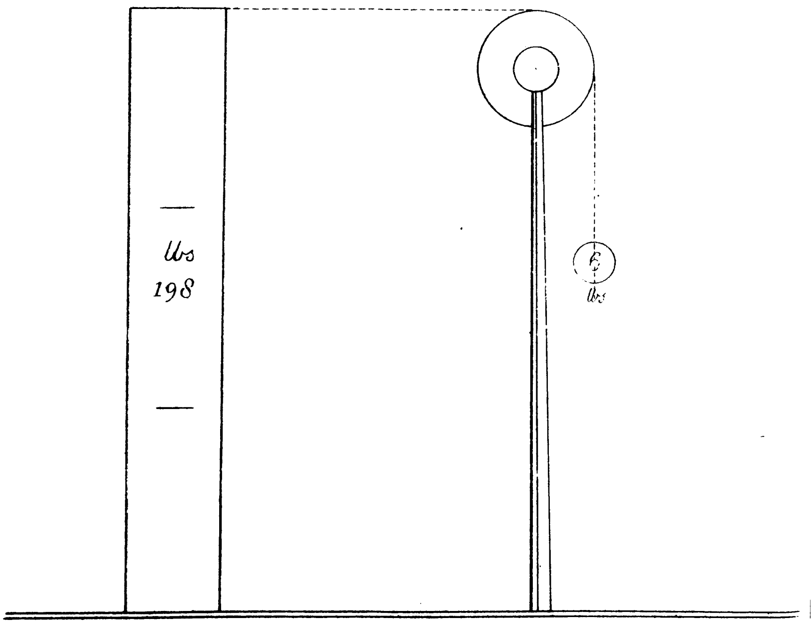


Fig. 33

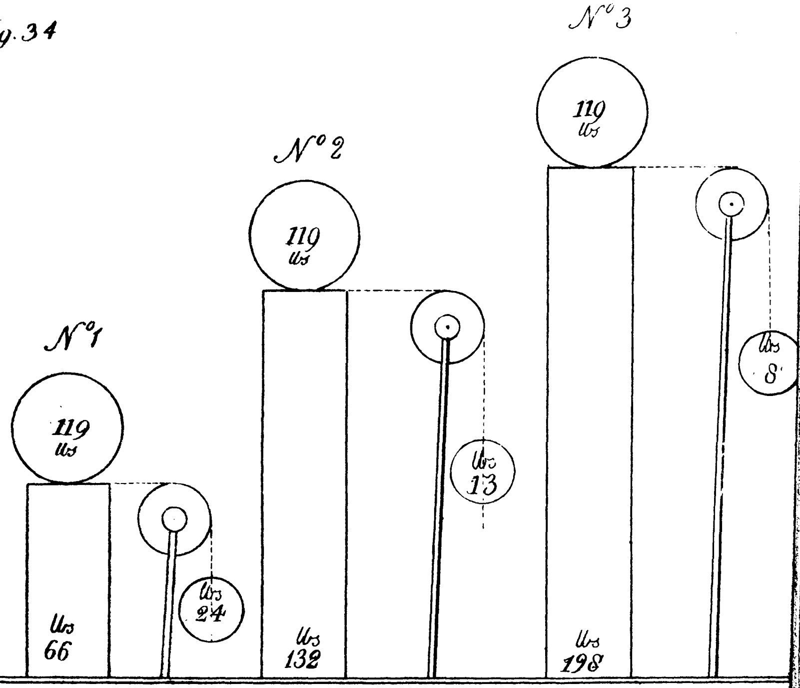


the tackling of our power to such a part of our machine, as when the power is in action, their line will be parallel to the road, and all hitchings, for fixing traces to, ought to be contrived so as to raise or lower, according to the height of our power employed. The inattention to these circumstances is the sole cause, that little half-worn-out ponies may be seen drawing large carts upon the road with ease (for, on examination, we shall find, that the small stature of the animal causes the draught line to be parallel to the centre of the wheels, which are generally high ones), while, we may observe the tall, high-conditioned horse, yolked to a fashionable, low-wheeled vehicle, fatigued and jaded by the draught, and, perhaps, is passed by the higler with this poney, to the great surprise, and indeed, chagrin of the driver; the horse, from his height, causing a very oblique line of draught, thereby taking a great portion of the absolute weight, which obliquity of line is increased the nearer the animal is placed to his work, and which is generally done, though absurdly, to ease the draught; but the poney in the cart, taking his line of traction parallel to the centre of the wheel, combines all the advantages of the machine, which the other destroys by his height.

I come now to consider the relative weight of wheels to their burden and required draught, and the further remarks on their height. Having pointed out, that all sized wheels draw easiest from their centres, I shall endeavour to prove, that wheels increase in power on level road *ad infinitum*, in proportion as they increase in height.

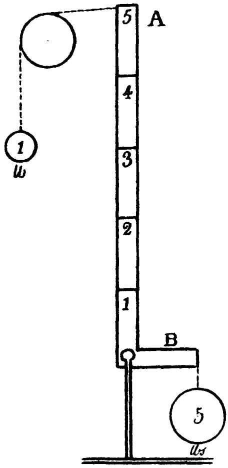
In order to solve these suggestions, I shall suppose the under spokes of two unequal sized wheels to be represented by the pillars A and B (see Fig. 32), the one double the height of the other, and each unincumbered by any weight, and to be moved by a central line C C, over the pullies D and E. Suppose the whole weight of No. 2 to be 66lbs. we shall find $\frac{1}{11}$, or about 6lbs. will pull it down, which may be considered the relative weight. Suppose No. 1 double the height of the same thickness, and double the weight, or 132lbs. we shall find that $\frac{1}{22}$, or 6lbs. still, will pull this down. Here we see this double height and weight takes just the same as the other. Again, suppose the pillar three times the height of No.2, and of treble the weight, or 198lbs. we still find that no disadvantage arises, but that $\frac{1}{33}$, or 6lbs. still will pull it to the ground. So that although the body is treble the weight of the first, the draught remains the same. This simple experiment is conclusive that the weight is no material drawback, it appearing a singular fact that the increase of weight from each additional height (which in the wheel follows the proportion of the pillar) becomes a counterpoise to the additional length of lever. Therefore I think it will be acknowledged, that high wheels have no disadvantage in this respect. I shall now endeavour to shew in what manner, and what advantage their height yields, by supposing these pillars to carry a weight, by which, in principle, it approximates to the real wheel carrying burden (ex. Fig. 34). Suppose each to carry 119lbs. we shall find $\frac{1}{5}$ of ditto, or 24lbs. will pull down No. 1, and that the next pillar, which is double the height and weight, carrying likewise 119lbs. will be pulled down by about $\frac{1}{9}$ of ditto, or 13lbs. and that the pillar No. 3. carrying 119lbs. although three times the height and weight of the first, will be pulled down by about $\frac{1}{15}$, or 8lbs. Here we see that this weight, at the several successive heights, brings out the lever-like principle of this pillar, and acts similar to the weight at the several gradations of the common steelyard—the weight from its quantity of gravity rendering the pillar more and more top-heavy at each elevation; and we shall find that the less proportion the pillar bears to the weight on its top, the less power in proportion will be required. Now, in applying this principle to the horse and carriage, as it ap-

Fig. 34



N° 1
119 lbs
lbs 66
lbs 24
N° 2
119 lbs
lbs 132
lbs 13
N° 3
119 lbs
lbs 198
lbs 8

Fig 35



A
5
4
3
2
1
B
1 lb
5 lbs

pears that the power required to move the high pillar, No. 3, is only about $\frac{1}{3}$ of that required to move No. 1; it follows that one horse would draw a given weight on a wheel of a certain height, with nearly the same ease that three horses would draw it on one of $\frac{1}{3}$ of its height, provided they draw in a line with the centre of the wheel, which in all cases is essential. This advantage of the high wheel is most easily and simply to be deduced from that well known modification of the common lever, or steelyard, the angular lever, with its fulcrum at its angle, and with one arm upright (see Fig. 35). Here we see, that 1lb. at the upper part of the arm A, will counterpoise 5lbs. at the first division of the other arm B.; but the lever in the wheel is much more advantageous, because the resistance to be overcome is not removed from its fulcrum, but remains at that point alone, and consequently requires less power to move it. I trust I have now made out that wheels really do increase in power *ad infinitum*, as they increase in height; however, I shall leave it to the candour of the reader. From these considerations and experiments, it appears that the wheel, as I before observed, is only a convenient vehicle for facilitating draught (its own weight on level road having nothing to do with the draught), its increase of height causing the line of gravity, when pulled from over its centre (which, when in action, is always the case), to take a greater distance on the ground just in proportion to that increase; so that the weight of the wheel itself (on level road particularly) becomes of no consideration, as it takes the same power to draw a wheel of three feet as one of nine feet. But here no doubt it will be asked, how will this additional weight act up hill? In answer, I shall at present merely say, as it appears that although high wheels facilitate draught on level road, on the principle deduced from the inclined planes, or lengthened lever, yet in the actual wheel the weight increases, as before stated, in proportion to its increase of height; this increase of weight beyond a certain extent, will point out to us a criterion where to limit that height, for I shall shew that there is a given proportion of weight the wheels must bear to their burden, which we cannot exceed, in order that their advantage of height may not be destroyed up hill; and herein may be said to rest the whole practical difficulty respecting them. The particular elucidation of which, will form part of another work (to which it more particularly belongs) I intend to publish, wherein I trust I shall clearly point out to what height they may be extended with advantage, so as always to have the superiority of the low wheel in travelling up hills of the greatest inclination carriages meet with in this country. Indeed, I may say, from the foregoing explanation of the wheel-lever, that high wheels may, by a judicious arrangement of their burden, be rendered completely subservient to our purpose in any situation facilitating the draught up hill in the same proportion that they do on level road, for the power, although remaining not quite the same, the length of the lever, by shifting its burden forwarder, will enable it to overcome the gravity of the wheel (which in this situation, is acting in a contrary direction to the power), with an advantage approximating to an arithmetical series, consequently corresponding to the quantity of absolute weight, which otherwise would, of its own gravity, fall behind the fulcrum of the wheel from the inclination of the hill.* I shall now, at all events, from the foregoing principles, lay it down as a rule, that a wheel as high again as another (applied to a carriage just of sufficient weight for two horses), would be nearly, notwithstanding its weight, equal to the power of the second horse; so that those who keep but one horse, and require occasionally to have carried double the weight, may, by keeping a pair, or set (according to the carriage, peculiarly and easily adapted to admit their application), of wheels, which will not, to use the common expression, eat at night, of the height here stated, obtain all the advantage, without the expense, of an additional animal, not omitting to strictly adhere to the principles of draught, before laid down.

These principles, if they may be so called, may be applied at present, even to an extravagant degree, with the greatest advantage, particularly, I think, to those vehicles which are used principally for purposes of burden, and in which elegance of appearance is not an object compatible with the utility.

Having given one general rule, for assisting the power by the height of the wheel, and, I trust, having proved their superiority in point of draught, I shall now beg to leave the contents of the foregoing pages to the judgment of those, who use and construct carriages, and to apply the principle as the elegance, or other considerations, will admit. I shall here close these remarks by a few observations; there is no doubt in my mind, as may be inferred, that the present system of wheeling carriages is radically wrong, and that it tends to the destruction of a vast capital, as well as endangers continually a number of, (and is certainly the cause of the loss of many individual) lives; notwithstanding which it is such a favourite, that any other at present stands no chance, however eligible it may appear, of being adopted; consequently, this must be left to time and its own strength, to wade through (which it must eventually) that sea of prejudice, whose tide, at present, appears not to be stemmed. In connecting the immense disadvantages of dished and low wheels with narrow tyres, small surfaces to axles, and the prevalent injudicious arrangement of weight and draught, we cannot wonder at the just and general complaint by gentlemen of the excessive draught of their carriages.

However, I beg, with great deference, to submit it as my humble opinion, that were the system, here pointed out, that is, higher and upright wheels, broad tyres (these particularly for broad-wheel waggons, and carts of heavy burden) cylinder arms, with large surfaces, moderately long carriages, so as to get the weight lower, flat roads, and a judicious arrangement of weight, and of the line of traction) adopted subject to the improvement of abler hands, the internal commercial advantages would be incalculably great, and that it is a subject deserving the consideration of the Legislature, under whose patronage alone it is likely to be brought to perfection.

Having submitted these mere outlines of the principles of action in carriages, I beg leave to say, I shall shortly submit to the public a more full explanation of their applicability to wheel-carriages of every description, and on every principle now in use (wherein I shall start and answer such objections as they will possibly admit), illustrated by a series of correct engravings from drawings executed by myself, in which I shall point out the several defects and improvements, connected with their present construction; together with some other useful remarks incident to the work: from which, noblemen and gentlemen, and others, may found a correct judgment of the only proper construction (as far, I trust, as they will own necessary) for any carriage they may have occasion to have built; and be no longer left in the dark on the subject, from the varying and contrary opinions of the trade; reducing this branch of mechanism to fixed and certain principles, not to be trampled on by the insidious, or grossly evaded by the ignorant.

THE END.

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